MATHEMATICS TEACHING RESEARCH JOURNAL 128
WINTER 2022
Vol 14, No 5

Views on Mathematical Giftedness and Characteristics of Mathematically Gifted Students: The Case of Prospective Primary Mathematics Teachers

Gönül Yazgan-Sağ

Gazi University, Ankara, Turkey

gonulyazgan@gazi.edu.tr

Abstract: Mathematically gifted students are mostly getting their education in mixed classrooms. Teachers should be able to recognize mathematically gifted students to be responsive to those students' needs along with other students in their classrooms. The current study aims to reveal prospective primary mathematics teachers' views about mathematical giftedness and the characteristics of mathematically gifted students. The participants of this qualitative study are 11 prospective mathematics teachers who take their education in a four-year primary mathematics teacher education program at a state university in Turkey. Two focus group interviews are conducted with the participants. The row data were analyzed by using descriptive analysis. The findings reveal that prospective teachers associated mathematical giftedness with various concepts such as social environment and effort. The participants' views on the characteristics of mathematically gifted students have varied in line with the literature. It also concluded that prospective primary mathematics teachers emphasized creative acts like re-formulating problems and finding unique solutions to the problems as indicators of being mathematically gifted.

INTRODUCTION

In the field of giftedness since the 1900s, there have been discussions on how this concept can be defined and measured (Dai, 2010; Subotnik, Olszewski-Kubilius & Worrell, 2011; Ziegler & Heller, 2000). Similarly, there is also no consensus on a clear and universally accepted definition of mathematical giftedness (Karp, 2009; Mann, 2006). Mathematical giftedness is traditionally related to scoring above the 95th percentile on various standardized tests (Sheffield, 2003). However, mathematically gifted students demonstrate their talents in different forms (Gavin, Firmender & Casa, 2013). Recent literature also shows other factors as such motivation and persistence can be efficient to describe mathematically gifted students. According to recent studies, mathematical giftedness consists of two components that are mathematical ability and mathematical creativity (Kontoyianni, Kattou, Pitta-Pantazi & Christou, 2013). Mathematical giftedness refers to not just a high ability to do mathematical computations and get high marks in examinations, it also refers to a remarkably high ability to reason and understand in a mathematical context (Miller, 1990). Sheffield (1994) also indicated that there are many abilities

and characteristics describing mathematical giftedness. Mathematical ability commonly is manifested in accomplishing a task in the classroom context. However, it can be related to the capacity to learn and master other mathematical ideas and skills namely potential skills. Thus, this ability is not fully observable, only deduced from the performances of the student (Koshy, Ernest & Casey, 2009).

There are various studies examining the characteristics that may indicate giftedness in mathematics (Leikin, 2009; Karp, 2009; Singer, Sheffield & Leikin, 2017; Sriraman, 2004; Sriraman, Haavold & Lee, 2013, Yazgan-Sağ, 2020). Krutetskii (1976) carried out a pioneering work in this field by examining the structure of mathematical abilities for 12 years. He defined giftedness in mathematics as a unique combination of mathematical abilities that emerge during the successful execution of a task. In addition, Krutetskii (1976) used the term "mathematical cast of mind" to describe the tendency of mathematically gifted students to view the world around them through a mathematical lens. "They have a tendency to discover number bonds and mathematical relationships everywhere, to follow their own personal pathways to find a solution, and to produce novel ideas of some value" (Dimitriadis, 2016, p.223). In this sense, gifted students in mathematics have flexibility in mental processes and the ability to generalize mathematical relations and operations quickly and thoroughly (Singer, Sheffield, Freiman & Brandl, 2016). There is also another approach that refers to mathematical promise while considering mathematical giftedness. A mathematical promise is described as a function of ability, motivation, belief, and experience or opportunity (Sheffield et al., 1999). Mathematically promising students are mentioned as potential leaders and problem solvers in the future" (Sheffield, 1999). Discussing whether mathematically promising students are mathematically gifted, "mathematical giftedness is regarded as an emerging promise or high ability with mathematics relative to one's peers" (Reed, 2004, p. 91). Although there are different perspectives on describing mathematically gifted students, the literature mostly agrees that they can do mathematics that older students can do, or engage in mathematical thinking in a different way than their peers. It can be said that the mathematical promise possibly includes mathematical giftedness. Freiman (2003) described the characteristics of gifted students in mathematics according to the studies he examined. Mathematically gifted students

- love math (spending time on mathematics, seeing beauty in mathematics, enjoying doing math);
- want to learn more about mathematics (being highly motivated, being curious, being persistent, having exploratory orientation; being an entrepreneur; having a broad interest);
- think about the situations they encounter mathematically (gathering and organizing information; formulating situations; analyzing facts, patterns, and relationships; generalizing; reasoning abstractly; counting and calculating; interpreting data; proving and explaining logically);
- exhibit behaviors that increase their chances of succeeding in a mathematical task (hard

work; having long attention; having a good memory; being flexible; quickness in thinking; reflecting; critical thinking; focusing; finishing a job; being able to convey the results in verbal / writing; attention to detail; seeing the whole structure; intuitive thinking; being in a race).

However, it should be noted that these indicators should not be used as a set of criteria showing that students are gifted in mathematics. Gifted students in mathematics may not display all of the characteristics. In addition, the indicators of those characteristics may appear at different times depending on the development of students (Singer et al., 2016). Considering the literature, gifted students in mathematics can be described as individuals who have the ability to distinguish, abstract, generalize, and reason mathematical structures; the ability to think flexibly and reverse mathematical operations. They also have the ability to think analytically and intuitively, and to pose alternative problems related to the problems they solve. Lastly, they can perceive and work with highly complex structures (Krutetskii, 1976; Miller, 1990; Sriraman, 2003; Van Harpen & Sriraman, 2013; Yazgan-Sağ, 2019). It has been observed that gifted students especially prefer challenging problems in problem-solving environments (Shore & Kanevsky, 1993). Again, these students are the students who have an intuitive awareness of discovering mathematical proofs and principles (Sriraman, 2004).

The needs of mathematically gifted students differ from other students in a learning context. Mathematics teachers mostly tend to favor high achievers and ignore other indicators that point out giftedness in mathematics. Thus, revealing the characteristics of mathematically gifted students is essential for both the identification and development of the students (Sheffield, 1999). Mathematics teachers should also be able to notice mathematical giftedness indicators to be responsive to the needs of those students and to teach gifted students at an appropriate level (Reed, 2004; Sheffield, 2003). Although the literature review reveals several studies related to the characteristics of mathematically gifted students (Karp, 2009; Singer et al., 2017; Krutetskii, 1976; Sriraman, 2004; Sriraman, Haavold & Lee, 2013), there are limited studies on mathematics teachers' views of those students (Leikin & Stanger, 2011). Mathematically gifted students commonly take their education in heterogeneous classrooms (Reed, 2004). In this sense, thinking and reflecting on mathematical giftedness and mathematically gifted students can trigger prospective primary mathematics teachers' to notice those students in their future classrooms. This study aims to reveal the readiness of prospective primary mathematics teachers who will also teach mathematically gifted students in their classrooms. Therefore, the purpose of this study is to investigate prospective primary mathematics teachers' views related to mathematical giftedness and the characteristics of mathematically gifted students.

METHOD

The current study aims to explore prospective primary mathematics teachers' views on mathematical giftedness and the characteristics of mathematically gifted students. The participants of the qualitative study were prospective primary mathematics teachers studying a four-year teacher education program at the Mathematics and Science Education department of a state university in Turkey. They were attending the "Teaching Methods" course in the 6th semester of the program, and the instructor of that course was the researcher of this study. The researcher asked questions related to giftedness and mathematical giftedness in one of the lessons of this teaching methods course. These questions provided an environment for a discussion about the issues in mathematical giftedness literature. These open-ended questions were "What do you understand from the term 'giftedness'?"; "What do you understand from the term 'mathematical giftedness'?"; "What do you know about the mathematically gifted students? Have you ever had any experience with such students?"; "What could be the characteristics of the mathematically gifted students for you?"; "What could be the characteristics of the teachers of the mathematically gifted students for you?". After this lesson, the instructor asked the prospective teachers whether they want to participate in a study that aims to reveal their views about these questions. Eleven of 23 prospective mathematics teachers voluntarily agreed to participate in this study. While presenting the data, prospective primary mathematics teachers were named Bilge, Ceren, Mira, Kader, Ferhat, Havva, Sibel, Ezgi, Melis, Zeynep, and Filiz (pseudonyms). Two focus group interviews were conducted; one with 5 participants and the other with 6 participants. Those interviews were video-typed and lasted approximately 100 minutes. These focus group interviews allowed all prospective mathematics teachers to reflect on other prospective teachers' thoughts (Patton, 2002). The researchers employed related prompts during the interviews, in this way prospective mathematics teachers stayed focused on these open-ended questions. Descriptive analysis was used while coding the row data. Within the scope of this study, the data regarding mathematical giftedness and characteristics of mathematically gifted students will be presented in the findings.

FINDINGS

The findings will be presented in two sections. The first section aims to provide information about the prospective mathematics teachers' views on mathematical giftedness. Besides, the participants' views of the characteristics of mathematically gifted students are included in the second section of the findings.

Prospective Primary Mathematics Teachers' Views on Mathematical Giftedness

This section of findings describes briefly the prospective primary mathematics teachers' views of mathematical giftedness. The participants associated mathematical giftedness with several concepts. One of the issues that emerged in the focus group interviews was innate ability. Most of them hve argued that being mathematically gifted is innate. Here are a few opinions of the

participants:

> Bilge: I think it starts from birth.
>
> Ceren: It comes from birth. […] I mean it is not something that will occur with training afterward. For example, a person has an interest in wrestling; he comes to the highest level in wrestling and becomes gifted in that field. But I don't think it's the same for other disciplines. Am I wrong?

As seen above, Bilge and Ceren both thought that people are born with mathematical talents. However, Ceren added that this may not be true in other disciplines which require muscle strength. The participants also discussed whether mathematical giftedness could be improved. Mira came up with the idea that talent cannot be improved: "I think talent is something innate, I don't think it's something that is developed later. Whatever it is, it doesn't change. It stands still there" As seen from the excerpt, Mira thought that talent is something fixed. On the other side, Filiz objected to this idea by saying "even average people come to a certain level through hard-working, so I believe talent can be improved by hard-working". Similar to Filiz, most participants stressed that effort is an important factor in improving talent.

The dichotomy among the prospective teacher also continued with the loss of mathematical talent. Most of the participants agreed with this statement: if people don't work on their mathematical abilities, then they can lose their talent. However, they highlighted the argument that social environment also has influence on the improvement of mathematical giftedness. Zeynep's explanation is as follows:

> Zeynep: I think the social environment in which mathematically gifted students live is very important. I mean, in the class if the teacher says "don't ask questions like that" or their peers say "what a stupid question", this may affect these students. Let's look at home, what if their families don't care enough or can't provide suitable conditions?

As seen from the above excerpt, the prospective teachers referred to both classroom and house environments in mathematical talent development. Some participants emphasized that describing mathematical giftedness can change according to the historical perspective. For example, Bilge thought that the definition of mathematical giftedness might differ depending on the time and said that "[…] In the past, people may have preferred memorization over writing." In the same manner, Sibel highlighted the historical context by saying "being the first person to memorize certain numbers may have been associated with mathematical giftedness in the past." A number of participants also related mathematical giftedness with IQ scores. Bilge and Ceren only shared their narrow knowledge of the content of the exam in which the IQ scores were determined and the meaning of the scores obtained in the test.

Prospective Primary Mathematics Teachers' Views of Characteristics on Mathematically Gifted Students

This section provides insights into the participants' views of the characteristics of mathematically gifted students. Most of them stated that these students have quick-thinking abilities. For instance, Ferhat expressed this ability by saying: "[…] because they reason and think quickly they can do mental computations and answer quickly". However, Ezgi didn't agree with her friends at this point and explained her thoughts:

> Ezgi: "Being quick is not a sign for me. Let's say these students answer the questions quickly, then I can be skeptical that they may be gifted. But if they can't answer quickly, I don't think that they are definitely not like that".

Ezgi also added that mathematically gifted students enjoy playing with numbers and like very complex operations. Then other participants agreed with the following statement: quick thinking is not the only condition for a being mathematically gifted student. In the same manner, Kader conveyed the statement:

> Kader: I don't think that quick thinking has much to do with giftedness. It may be related, but it may not be. They can catch the subject later than others, but they can develop a method more firmly. […] At first, they may not be able to understand the teacher's method, but later they may develop a method themselves.

As can be understood from Kader's statement, developing a new method and developing that method on their own is more notable than thinking quickly about being mathematically gifted. Then Ceren gave her reasons as follows: "If they don't accept everything and ask questions like 'where does that integral sign come from?', 'where did this formula come from?' then they may be gifted in mathematics." Melis also highlighted abstract thinking with the concepts that may be the characteristics of mathematically gifted students.

The prospective teachers have argued about getting high marks on the math exams. While some of the participants favored that being a hard-working student can be a sign of mathematical giftedness, others prioritized being consistently successful in activities. Here is a vignette that portrayed the thoughts of prospective mathematics teachers concerning students' acts and marks in the classroom context:

> Filiz: In general, they are the most hardworking in the class, I think of them as hardworking. Those are always first in class and school. They always feel like such a leader.
>
> Ceren: For example, if the students' success is continuous, if they show differences in the class many times, then they may be gifted.
>
> Sibel: I don't think that a student who consistently achieves the same level of success or even a very high level of success in the lessons and receives 100 continuously does not indicate that the student is gifted in mathematics. It just shows that they are hardworking students; I

don't think they are gifted.

Ferhat: For example, if they are constantly getting 100 without working, should we say this again?

Melis: They can perform above the expected class average. They just listen to the teacher and take high marks, what happens then?

Sibel: Maybe then we should have a look. I think it is unnecessary to even suspect otherwise.

As the dialog shows that participants have different views on the relationship between hard-working students and mathematically gifted students. Sibel insisted on the idea that hard-working and getting high marks in the exams may not be the characteristics of being gifted in mathematics. However, when Ferhat and Melis suggested new conditions such as getting high marks without working and performing above average, then Sibel agreed on such situations can be taken as a signal for the mathematical talent in students.

The prospective teachers denoted that being curious is one of the characteristics of mathematically gifted students. Bilge explained being curious as follows: "I think being more open to learning, and very curious about mathematical knowledge can be some criteria for being gifted". Zeynep remarked that mathematically gifted students are able to modify the conditions of a given problem:

Zeynep: In a given problem, they may reflect on the problem, such as "what would I do if that wasn't here if the problem had asked that". If they can turn a given problem into a different problem by reasoning like "I wonder what I would have done if it hadn't been there or if the problem had asked me something like this", that is, if they are playing with the problem, they may have mathematical talent.

Zeynep focused on a problem-posing act: re-formulating the mathematical problem that is known as one of the creative activities in the literature (Prabhu & Czarnocha, 2013; Silver, 1994). Similarly, other participants related certain creative characteristics to mathematically gifted students. A number of prospective teachers stated that thinking differently from their peers might be one of the characteristics of the mathematically gifted students:

Zeynep: They can get bored very quickly in class. […] They can have a different way of thinking or a different perspective.

Researcher: Different from who or what?

Havva: Different from their age group. For example, when solving a logic problem, they find their way that is something unique, or they think something different. They say different things compared to their peers or people in that society, they produce different solutions and, you know, they break out of the routine.

Zeynep: They don't solve a problem in the way we expect in their age group. [...] And they

have found their way, they think about the problem differently than we think, that is, differently from what we expect from that age.

Melis: In fact, to be able to grasp immediately, to be able to bring different perspectives.

Sibel: That is, finding the right solution that is unique to them, originality.

Here, the participants indicated that these students may think more about the solutions to the problems compared to their classmates. Zeynep also asserted that the lessons can be boring for mathematically gifted students. Sibel and Havva revealed finding a unique solution is one of the characteristics of these students. The prospective mathematics teachers noted that flexible movements between subjects can be seen as a mathematical talented behavior. Here is Ezgi's explanation: "It is very important to be able to switch from subject to subject. I think they are able to apply a mathematical subject or formula they learned in chemistry and physics". Flexibility is also relevant to creative acts in doing and learning mathematics (Sriraman, 2005). Only Havva stated her thoughts on creativity explicitly:

Havva: I think they are creative people, I mean, every gifted person is also a creative person.

Researcher: What do you mean by saying creativity?

Havva: Actually, creativity covers what the friends say here. That is, they think differently, and produce different solutions. Also, they do this all the time.

DISCUSSION AND CONCLUSION

This qualitative study examined fourteen prospective primary mathematics teachers' views related to mathematical giftedness and characteristics of mathematically gifted students through focus group interviews. Findings revealed that the prospective teachers have different views on the mentioned concepts. Since the participants did not take any specific course related to (mathematically) giftedness, similar to Leikin's (2011) statement, most of the prospective teachers' views were directly connected with their personal experiences. Prospective primary mathematics teachers thought that mathematical giftedness came from birth. This perspective is relevant to the belief people are born with fixed abilities which is one of the myths (Sheffield, 2017). Nonetheless, the prospective teachers also highlighted that effort will improve the mathematical talent of the students and conveyed the idea that "To develop mathematical talent a person has to work hard" (Leikin, 2020, p. 323). The effort is included while describing mathematical ability (Koshy et al., 2009). Participants' views revealed that one of the concepts that may influence mathematical giftedness was the social environment (Renzulli, 2000). The prospective primary mathematics teachers stressed the significant role of the environment in nurturing mathematical ability in gifted students. They emphasized the historical perspective on describing mathematical giftedness. The participants stated their narrow knowledge of IQ scores which are traditionally accepted as evidence of giftedness (Yazgan-Sağ & Argün, 2020).

The prospective teachers expressed that quick thinking is one of the prominent characteristics of mathematically gifted students. This finding is in line with Paz-Baruch, and her colleagues (2014) demonstrated that speed is inherent to mathematical giftedness. However, some participants stated that the absence of speed does not necessarily mean the absence of mathematical giftedness. Those participants acknowledged developing new methods while solving problems as a sign of being mathematically gifted. Also, participants asserted that mathematically gifted students have characteristics like questioning the reasons, thinking abstractly, and solving complex problems. These cognitive characteristics are also stated in the literature that may be the strong predictors of mathematical giftedness (Davis & Rimm, 2004; Singer et al., 2017; Krutetskii, 1976; Paz-Baruch, Leikin & Leikin, 2022). Another discussion among the prospective teachers was about getting high grades in the mathematics examinations. Some of those argued that getting high marks even without working hard and demonstrating high mathematical performance continuously can be an indicator of being a mathematically gifted student. This statement is also supported by previous research (Krutetskii, 1976). Leikin (2020) suggested, "A student is mathematically gifted if s/he exhibits a high level of mathematical performance within the reference group and is able to create mathematical ideas which are new with respect to his/her educational history," (p. 318). As Leikin stated mathematical giftedness is connected to mathematical creativity in the literature (Mann, 2006; Prabhu & Czarnocha, 2013/2014; Sriraman, 2005). Similarly, the prospective primary mathematics teachers related various creative acts such as posing problems and trying to find a unique solution with mathematically gifted students.

This study revealed that the participants' views of mathematical giftedness and mathematically gifted students are mostly binary. It may stem from the concepts concerning mathematical giftedness that differ from one society to another. For educators, it is critical to know the literature about mathematically gifted students. With proper training, teachers can become successful in meeting the needs of mathematically gifted students (Karsenty, 2014). Both theoretical and empirical studies may help prospective teachers to expand their knowledge, but this knowledge may not be enough to recognize mathematically gifted students. Therefore, "in order to develop the creativity of future teachers, it is crucial to familiarize them with a variety of pedagogical situations that can genuinely expand their conception of what is possible in the classroom." (Karp, 2010, p. 279). Prospective primary mathematics teachers should be in an environment where they can acquire both theoretical knowledge and experience with mathematically gifted students.

ACKNOWLEDGEMENT

The author would like to thank Gazi University Academic Writing Application and Research Center for proofreading the article.

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